THE REPUBLIC OF THE PHILIPPINES
MINISTRY OF PUBLIC WORKS AND HIGHWAYS
NATIONAL IRRIGATION ADMINISTRATION

FEASIBILITY REPORT ON THE PAMPANGA DELTA DEVELOPMENT PROJECT

APPENDIXES VOLUME II

APPENDIX IV FLOOD CONTROL
APPENDIX V AGRICULTURE AND AGRO-ECONOMY
APPENDIX VI IRRIGATION AND DRAINAGE
APPENDIX VII INLAND FISHERIES
APPENDIX VIII SEAWATER INTRUSION
APPENDIX IX ORGANIZATION AND MANAGEMENT
APPENDIX X EVALUATION

FEBRUARY 1982

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

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ABBREVIATIONS

Abbreviations used in this report are listed below:

1. Length and Height

mm : millimeter
cm : centimeter
m : meter
km : kilometer
MSL : mean sea level
EL : elevation

2. Area

cm^2: square centimeter
m^2: square meter
km^2: square kilometer
ha : hectare
MSM : million square meter

3. Volume

lit, l : liter (= 1,000 cm^3)
m^3 : cubic meter
MCM : million cubic meter

4. Weight

mg : Milligram
g : gram
kg : kilogram
t (ton) : 1,000 kg

5. Time

sec : second
min : minute
hr : hour
yr : year

6. Electric Measures

kV : kilovolt
kW : kilowatt
kWh : kilowatt-hour
MW : megawatt
MWh : megawatt-hour
GWh : gigawatt-hour

6. Other Measures

% : percent
PS : horse power
°C : centigrade
m^3/sec, m^3/s : cubic meter per second
lit/sec/ha, lit/s/ha : liter per second per hectare
cm/sec, cm/s : centimeter per second
t/ha : ton per hectare
ppm : part per million
No(s). no(s) : number(s)
SPT : standard penetration test

8. Currency

US $: US Dollar
₱ : Philippine Peso (US $1.00 = ₱7.50)

9. Other Abbreviations

ADB - Asian Development Bank
BPW - Bureau of Public Works
BCGS - Bureau of Coast and Geodetic Survey
BS - Bureau of Soils
BFCD - Bureau of Flood Control and Drainage
BPI - Bureau of Plant Industry
BAI - Bureau of Animal Industry
BAEcon - Bureau of Agricultural Economics
BAEx - Bureau of Agricultural Extension
BFAR - Bureau of Fisheries and Aquatic Resources
GOP - Government of the Philippines
IBRD - International Bank for Reconstruction and Development
JICA - Japan International Cooperation Agency
MND - Ministry of National Defense
MPH - Ministry of Public Highways
MPW - Ministry of Public Works
MPWH - Ministry of Public Works and Highways
MAR - Ministry of Agrarian Reform
MWSS - Metropolitan Waterworks and Sewerage System
NIA - National Irrigation Administration
NFA - National Food Authority
NPC - National Power Corporation
NEDA - National Economic and Development Authority
NWRC - National Water Resources Council
FSDC - Farmer's System Development Cooperation
MRRTC - Maligaya Rice Research and Training Center
UPCA - University of the Philippines College of Agriculture at Los Baños
M-99 - Masagana-99 Program
PD/CS Area Development Project - Pampanga Delta/Candaba Swamp Development Project
OECF - Overseas Economic Cooperation Fund
PAGASA - Philippine Atmospheric, Geophysical and Astronomical Services Administration

NSDB	-	National Science Development Board
RP	-	Republic of the Philippines
TFFCRA	-	Task Force for Flood Control and Related Activities
UNDP	-	United Nations Development Program
USAID	-	United States Agency for International Development
IRRI	-	The International Rice Research Institute
NASUDECO	-	National Sugar Development Corporation
PASUDECO	-	Pampanga Sugar Development Corporation
CIS	-	Communal Irrigation System
RIS	-	River Irrigation System
PIS	-	Pump Irrigation System
USBR	-	United States Bureau of Reclamation
PRSC-PMO	-	Pampanga River Control System Project Management Office

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CHAPTER 1 INTRODUCTION

The study of flood control was carried out stepwise, Phase I and Phase II. The study on Phase I is to formulate the most optimum basic plan of flood control. As a result of the study adopting 100-year return period as design flood, the plan by means of the channel improvement of the Pampanga River was identified as the most optimum flood control plan. The results of the study on Phase I are described in Appendix I.

The study on Phase II is to conduct the feasibility study for finalization of the optimum plan. From the viewpoint of the implementation of the project, the stepwise flood control plan was studied adopting 20-year design flood. The basic course of the study of the flood control plan on Phase II is as follows:

a. The flood control plan by means of channel improvement with 100-year design flood as the basic plan.

b. The stepwise flood control plan by means of channel improvement with 20-year design flood as the feasibility study.

This Appendix presents the results of the study of flood control plan on Phase II. The evaluation of the proposed flood control plans is not included in this Appendix.

CHAPTER 2 BASIC FLOOD CONTROL PLAN

2.1 Outline of Basic Plan

The purpose of channel improvement of the Pampanga River is to protect the land of the South Candaba Swamp and the land downstream below Sulipan, Calumpit against flooding from the Pampanga and Angat Rivers by constructing levee along the rivers. The improvement works mainly consist of embankment of levee, widening and excavation of the river channel on the stretch between Candaba and near Manila Bay.

At present, the Pampanga River branches into two channels at about 15 km from the rivermouth, i.e. the main Pampanga River flowing directly to Manila Bay and the Bebe San Esteban Cutoff channel flowing out from the Pampanga River to the Pasag River. For channel improvement on this stretch, it is studied about the following two methods.

Method - 1: Improvement of the Bebe San Esteban Cutoff Channel

For the Bebe San Esteban Cutoff Channel, embankment of levee, widening and excavation of channel will be executed in order to increase carrying capacity of the channel. For increased flood discharge from the Pampanga River to the Pasag River, the channel of the Pasag River will be excavated to keep the flood water level at present. During flood time, all flood discharge from the upstream will be confined in the Bebe San Esteban Cutoff Channel constructing flood gate at the left side of the diversion point.

Method - 2: Improvement of the main Pampanga River

For the main Pampanga River, embankment of levee, widening and excavation of channel will be executed in order to increase carrying capacity of the channel. For the Bebe San Esteban Cutoff Channel, it will be kept the present condition, but the heightening of the existing levee will be carried out.

The discharge distribution of 100-year design flood for the above two methods are shown in Fig. 2.2. The river channel alignments of the methods are planned as shown in Fig. 2.3, and the cross-sections of the channel of Method-1 are shown in Fig. 2.4.

The work quantity and direct construction cost of the methods are estimated as shown in Table 2.1. They are summarized as follows:

Item	Unit	Method-1	Method-2
1. Embankment of Levee			
Pampanga River	10^3m^3	-	1,330
Bebe S.E. C.O.C.	10^3m^3	1,205	1,460
Pasag River	10^3m^3	265	-
2. Excavation of Channel			
Pampanga River	10^3m^3	-	11,840
Bebe S.E. C.O.C.	10^3m^3	9,480	1,460
Pasag River	10^3m^3	22,630	-
3. Construction of Outlet	nos	6	4
4. Construction of Fishpond Intake	nos	-	26
5. House Compensation	ha	50	550
6. Land Acquisition	nos	825	1,450
7. Direct Construction Cost	₱10^6	379	239

The above result shows that the construction cost of Method-2 is lower than that of Method-1. Therefore, the methods of the improvement of the main Pampanga River on the stretch below Bebe Masantol is adopted in this study. For the Bebe San Esteban Cutoff Channel, the heightening of the existing levee is planned, as the top of the existing levee is lower than that of the proposed levee.

With regard to the Labangan Floodway, the floodway is presently under construction in the second stage by MPWH. The channel is being excavated to a bottom width of 80 m. The carrying capacity after completion of the channel is estimated at about 500 m^3/s. The plan in the second stage of the Labangan Floodway does not include construction of levee. The construction of levee is therefore planned on the both sides along the floodway within the existing right of way, in order to increase bankful capacity to 1,850 m^3/s.

2.2 Design Flood

In this present study, 100-year return period for the basic plan is adopted as design flood which is the standard level adopted by MPWH flood control scheme. Using the hydraulic simulation model, the flood discharge distribution for the existing channel condition is analysed as shown in Fig. 2.5. Then the flood discharge distribution for the improved channel condition by the basic plan is analysed as shown in Fig. 2.6.

2.3 Project Works

2.3.1 Design Criteria

a. A series of the topographic maps of 1/25,000 scale are used for design of low-water channel and levee alignments.

b. The topographic maps of 1/5,000 scale and the cross-sections surveyed by MPWH are used for design of structures.

c. Data on river cross-sections with interval of 1-2 km surveyed by MPWH are used for design of river cross-sections.

d. Data on soil property investigated by the Team are used for design of construction works.

e. Manning's roughness coefficient "n" for design is adopted 0.03 for low-water channel and 0.05 for high-water channel.

f. The followings are adopted for design of levee cross-section as standard values.

Design Discharge (m^3/sec)	Free Board (m)	Crest Width (m)	Side Slope
less than 2,000	1.0	6.0	1 : 3.0
2,000 - 5,000	1.2	6.0	1 : 3.0
more than 5,000	1.5	6.0	1 : 3.0

In the backwater section of a tributary, the values mentioned above are determined that it is not lower than the values of the main river.

The banquettes of a levee are designed as specified that the banquettes are subdivided every 3 m to 5 m from the crown on the riverside if levee height is 6 m or more, and every 2 m to 3 m from the crown on the landside if the levee height is 4 m or more.

2.3.2 Alignment

The existing river channel meanders in several locations. To secure the stability of the proposed channel, it is planned to moderate excessive meandering by means of cutoff. The total length of meandering portions to be cutoff is about 2 km out of entire river length of 42 km. The proposed alighments of the river channel are shown in Appendix XI Drawings.

2.3.3 Profile

Based on the profile of the existing river channels as shown in Table 2.2, the proposed longitudinal profiles of the river channels for the basic plan are planned with regard to the Pampanga River, Bebe San Esteban Cutoff Channel, the Labangan Floodway including the lower part of the Angat River and the Maasim River as shown in Fig. 2.7.

2.3.4 Cross-Section

As the Pampanga River has extremely large seasonal fluctuation of discharge, composite-type cross section is planned in view of stabilizing the low-water channel and protecting the levee against flood flow. The high water level in the channel is designed as almost the same level as the existing levee on the right bank in view of the safety of embankment. Accordingly, the maximum flow velocity at flood time does not exceed 2 m/sec in low-water channel and is about 0.6 m/sec on the high-water channel. The width and depths of channels in the composite-type cross-section is designed based on the above flow velocities.

To treatment of excessive excavated soil and to create the high land for living space for transfer of the existing houses along the river, the base mound is planned to construct on the proposed levee site using dredged soil transported from the river channel.

With regard to the settlement of embankment, the settling thickness are estimated at 0.3 - 1.0 m based on soil mechanical analysis, and these values are considered for design of levee and base mound.

The proposed channel cross-sections are shown in Fig. 3.12. The details with regard to design of levee and base mound are described in Chapter 3.

2.3.5 Required Construction Works

The main works of the channel improvement are excavation of low-water channel and embankment of continuous levee along the river. The work quantities are summarized below:

Excavation of Low-water Channel:	46,380,000 m^3
Embankment of Levee:	10,500,000 m^3
Embankment of Base Mound:	35,880,000 m^3
Revetment	4,000 m
Outlet	19 places
Intake of Fishpond	26 places
Reconstruction of Bridge	3 bridges

2.3.6 Land Acquisition and Compensation

The land to be acquired for the implementation of the project works is approximately 670 ha in the stretch of Candabe-Sulipan and 1,860 ha in the stretch of Sulipan-Manila Bay. Of the total area of 2,530 ha, paddy field is 1,080 ha and fishpond is 1,450 ha.

The land of paddy field on the proposed low-water channel and levee sites is planned to be compensated. But the paddy field to be high-water channel is planned out from compensation, because the condition of the land would not be much changed by the implementation of the project. With regard to the fishpond to be confined in the proposed channel, the land is planned to be compensated, since the land to be high-water channel can not used for fishpond after completion of the proposed levee.

Total number of houses existed in the area of the proposed river channel is 6,700. These houses are planned to be transferred to newly created high land at the outside of the proposed levee.

2.4 Construction Cost and Flood Control Benefit

2.4.1 Construction Cost

Construction costs are composed of cost required for civil works, land acquisition and compensation, contingency and engineering and administration. Cost required for civil works is accounted by multiplying work quantity by unit cost. Cost for contingency is assumed at 15% of the total costs for civil works, acquisition and compensation. Engineering and administration cost is also assumed at 6% of the sum of the above-mentioned costs. The construction cost for the project is estimated at ₱1,081 x 10^6 at the 1981 price as shown in Table 2.3.

2.4.2 Flood Control Benefit

Benefits that will accrue from executing flood control works are given as effects of decrease in flood damages. Decrease in inundation areas by flood control project are estimated on the basis of the results of hydraulic analysis as shown in Table 2.4. The network of the hydraulic simulation model is shown in Fig. 2.8. Then, using these values, decrease in flood damages are estimated as shown in Table 2.5. The land to be aquired as right of way is evaluated in terms of negative benefit. The negative benefit is defined as the loss of the primary profit. The average annual benefit is estimated at ₱101.5 x 10^6 as shown in Table 2.6.

In addition to the value mentioned above, the benefits accrued from increased fish productivity in the fishpond area are estimated at ₱6.7 x 10^6 per annum as described in paragraph 3.6. Consequently, the flood control benefit in average amounts to ₱108.2 x 10^6.

CHAPTER 3 STEPWISE FLOOD CONTROL PLAN

3.1 Outline of Stepwise Plan

Although the flood control project with 100-year design flood is selected as basic plan, much fund will be required to implement such a big project. It is actual and practicable that such a large scaled flood control project be developed stepwise.

From this reason, three alternative stepwise plan are examined by the scale of design flood of 10-year, 20-year and 50-year. The results of the study are summarized below:

Plan	Design Flood (year)	Benefit (₱10^6)	Economic Cost (₱10^6)	IRR (%)
Plan - A	10	58.4	389	10.5
Plan - B	20	91.9	640	10.8
Plan - C	50	97.3	797	9.8

The above table shows that Plan-B has high economic value of IRR in compared with the other alternatives. The plan with 20-year design flood is therefore proposed as stepwise flood control project of the Pampanga River from the standpoint of high economic value and socio-economic conditions in the area.

On the other hand, the recorded highest water level since 1960 at the Candaba gauge station is EL. 8.24 m of the 1976 flood which corresponds to about 19-year return period. The river channel to be improved by the stepwise plan with 20-year design flood has a capacity to carry the said flood.

3.2 Design Flood

For stepwise plan, 20-year return period is therefore adopted as design flood. The flood discharge distribution for the existing channel and for the improved channel by the stepwise plan are analysed as shown in Figs. 3.1 and 3.2 respectively.

3.3 Project Works

3.3.1 General

The proposed river channel stretches for improvement are planned as same as the basic plan. The levee of the Labangan Floodway is planned to be completed in this step. The excavation of the channel, embankment of levee and construction of the related structures will be executed in this step on the level of 20-year return period. The proposed channel alignment, profiles, and cross-sections are shown in Appendix XI Drawings. The typical cross-sections of the proposed levee are shown in Fig. 3.3.

The proposed river channel improvement works comprise the construction of new levee in a length of 97 km, heightening of levee in a length of 36 km, excavation of low-water channel in a volume of 33 x $10^6 m^3$, revetment of 4 km and construction of related structures such as outlet culvert and bridge. The work quantities for the stepwise plan are shown in Table 3.1.

3.3.2 Design of Levee and Base Mound

Since a levee is constructed by soil, it is necessary to check its safety against external forces due to flood and others. In designing the cross-section of levee in this study, stability of levee is studied from the view points of slope failure, seepage and settlement.

(1) Stability of Levee Slope

Slope failure is generally classified into 3 types, namely; toe failure, base failure and slope failure as shown in Fig. 3.4. In checking such slope failure, critical height of slope and its stability factor are examined using a method, so-called the Tailor's Diagram as shown in Fig. 3.4.

The relation between critical height and stability factor is given in the following:

$$N_s = \frac{r_e H_c}{C} \quad \text{...} \quad \text{(A-1)}$$

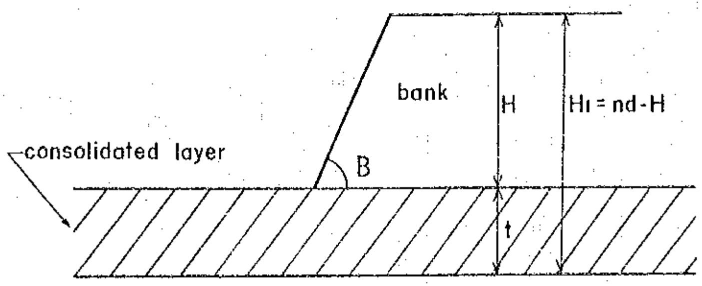
where, N_s: stability factor

r_e: effective unit weight of bank material

H_c: critical height

C: cohesion

t: thickness of consolidated layer



Using the Tailor's diagram, stability factor or safety factor is checked adopting the following conditions.

Stretch	B	t	H	H_1
	(degree)	(m)	(m)	(m)
P-12K - POK	18.3	4.5	4.6	9.1
POK - P8K	18.3	6.0	4.7	10.7
P8K - P28K	18.3	6.0	5.9	11.9

Remarks: H: height before settlement

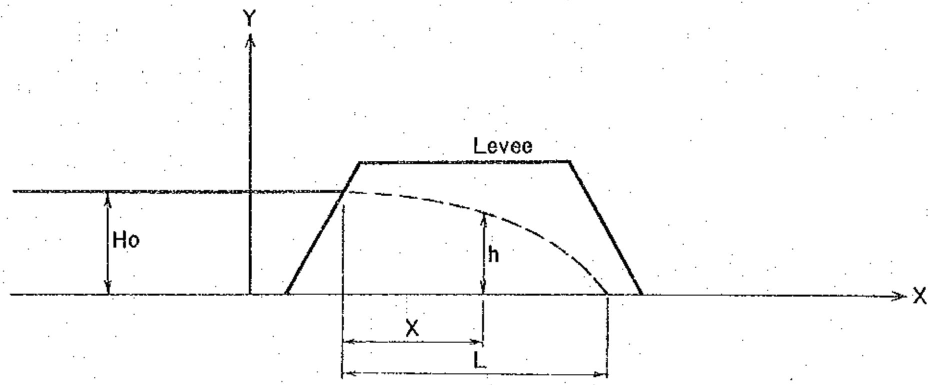
The effective unit weight of bank material (r_e) and cohesion (C) are assumed at 1.8 t/m^3 and 2.2 t/m^2 respectively, based on the results of the geological investigation. The estimated safety factors are as follows:

Stretch	Stability Factor Obtained from Proposed Slope		Stability Factor Obtained from Tailor's Diagram	Safety Factor
	$nd=\frac{H_1}{H}$	$Ns'=\frac{r_e \cdot H}{C}$	Ns	$N=\frac{Ns}{Ns'}$
P-12K - POK	2.00	6.2	3.8	1.6
POK - P8K	2.28	6.1	3.8	1.6
P8K - P28K	2.02	6.2	4.8	1.3

To determine the levee slope, the safety factor should be adopted the value more than 1.2. As the estimated factors exceed the critical value, the proposed levees with slope gradient of 1:3 will withstand against sliding.

(2) Seepage Line through Levee

Seepage line through levee is generally expressed as a parabolic curve which has a focus on the impermeable base as illustrated below:



Based on the Darcy's Law and the continuity equation, Dr. Mononobe derived the following formula.

$$\left.\begin{aligned} L &= C\sqrt{\frac{K}{r}\,Ho\,dt} \\ h &= Ho\left(1-\frac{X^2}{L^2}\right) \end{aligned}\right\} \quad \cdots\cdots\cdots \quad (A\text{-}2)$$

where, K: coefficient of permeability

Ho: mean water depth during dt hours

L: creeping distance of seepage line

C: constant (2.0 m/hr)

r: void ratio

dt: duration time of Ho

In order to determine the required width of levee, seepage line is examined adopting the stage hydrograph of design flood with 20-year return period as shown in Table 3.2. The values of K and r are assumed at 0.1 m/hr and 0.3 respectively, based on the results of soil investigation. The height of levee and duration of flood are as follows:

River	Sect. No.	Levee	Ho (m)	dt (hr)
Pampanga River	P20K	Existing	3.4 2.9	70 120
Pampanga River	P20K	Proposed	3.4 2.9	70 120
Pampanga River	P0K	Proposed	3.5 3.0	50 110
Labangan Floodway	L-4K	Proposed	1.8 1.5	50 80

The estimated creeping distance of seepage line are shown below:

River	Sect. No.	Levee	Ho (m)	L (m)
Pampanga River	P20K	Existing	3.4 2.9	17.9 21.6
Pampanga River	P20K	Proposed	3.4 2.9	17.9 21.6
Pampanga River	P0K	Proposed	3.5 3.0	15.3 21.0
Labangan Floodway	L-4K	Proposed	1.8 1.5	11.0 12.7

Fig. 3.5 shows the estimated seepage lines through levee. From this figure, it is recognized that the seepage lines of the levee do not reach to the slope of landside. Hence, the levee will withstand against seepage force due to flood.

(3) Settlement of Levee and Base Mound

For estimating the settlement of levee and base mound, 3 cross-sections are selected on the basis of geological condition and height of embankment. The cross-section is divided into 2 portions of base mound and levee, because of difference of its settling thickness.

The settlement due to consolidation is estimated by use of the following formula applying the values for the typical foundation layer as shown in Fig. 3.6.

$$d = h\frac{e_0 - e_1}{e_1 + 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (A-3)$$

where, d: settlement (m)

h: thickness of consolidated layer (m)

e_0: void ratio before loading

e_1: void ratio after loading

The values of e_0 and e_1 are determined based on the results of soil investigation. The stress after loading (P_1) is obtained from the relations as shown in Fig. 3.7.

The following values are used for the calculation of settlement.

Condition	Unit Weight (t/m^3)
1. Consolidated layer	
- above ground water level	1.70
- below ground water level	0.70
2. Sandy soil	
- above ground water level	1.80
- below ground water level	0.80
3. Dredged soil (sandy soil)	2.0
4. Banking by dredged soil	
- thickness = 1.0 m	2.0
- thickness = 2.0 m, upper 1 m	2.0
- thickness = 2.0 m, under 1 m	1.8

The settlement of levee and base mound are estimated as shown in Tables 3.3 and 3.4, under the following assumptions.

a. Although the ground surface is irregular depending on topographic condition, the base elevation is assumed to be level at the center of the mound.

b. Estimated settling thickness is expressed as a maximum value.

c. Settlement due to banking is expressed as value at the center of levee, and the weight of the base mound is included in the initial stress.

The settlement heights of levee and base mound are summarized below:

(Unit: m)

Stretch	Height of Base Mound			Height of Levee		
	Before Settlement	Settlement	After Settlement	Before Settlement	Settlement	After Settlement
P-14K - POK	2.0	0.5	1.5	2.6	0.3	2.3
POK - P8K	3.0	1.0	2.0	2.7	0.5	2.2
P8K - P28K	2.9	0.4	2.5	3.4	0.3	3.1

(4) Design of Levee and Base Mound

Levee Cross-section

Based on the study results, the slope of 1:3 is adopted for the proposed levee. On the other hand, since flooding duration is considerably long in the lower reaches of the Pampanga River, the levee with berm of 6 m is planned to be constructed on both for the river and land sides.

Base Mound

In order to create the elevated land for the houses to be transferred, the base mound is planned to be constructed at the outside of the proposed levee utilizing the extra dredged soil. The height and width of the base mound are determined below:

Station No.	Elevation of Base Mound (EL. m)	Width of Base Mound Stepwise Plan (20-yr) (m)
P-12K	1.20	140
P-10K	1.20	140
POK	3.00	260
P8K + 400	5.00	) 240
P10K	5.40	) 240
P28K	7.00	

3.3.3 Design of Structure

(1) Outlet Culvert

In order to drain the inland water, outlet culvert is planned to be constructed taking into consideration of drainage area and the existing culvert as shown in Table 3.5. 3 types of culvert are designed with the following conditions.

Type	Width (m)	Height (m)	Nos. of Culvert
A	5	4.5	3
B	2.5	2.5	2
C	2.5	2.5	1

The designed culverts of the said 3 types are shown in Appendix XI, Drawings. The quantity of the culvert to be constructed is listed in Table 3.6.

(2) Bridge

It is necessary to re-build the following 2 existing bridges by the implementation of the project.

Location		Width (m)	Length (m)
San Simon:	P16K + 1,300 m	3.8	140
San Luis:	P22K + 1,200 m	3.8	130

These bridges are presently being utilized as communication road connecting between the left and right sides of the river. To design of the bridges, location of the proposed bridge axis is determined on the basis of the proposed alignment of low-water channel and social conditions of surrounding area. The proposed San Simon bridge is planned to construct at the just upstream of the existing site, and the proposed San Luis bridge is planned at about 700 m upstream of the existing site. The type of the proposed bridges are designed as simple composite girder with effective width of 4 m and length of 225 m with 6 spans. The designed bridges are shown in Appendix XI, Drawings.

In order to protect the bank slope of the channel from erosion due to flow attacking, the revetment is designed taking into account the example in similar works of the project area. The proposed locations of the revetment is listed in Table 3.7, and the typical cross-section of the revetment is shown in Fig. 3.8.

3.4 Construction Cost

The construction cost of the project is estimated by the 1981 price and by the following assumptions.

a. Execution of the works is carried out by contracting system, and the civil works are carried out by contractors.

b. The construction equipment except dredger and their spare parts required for the works are arranged by contractors.

c. The government procures the dredgers and lends them to contractors to carry out the dredging works by use of them.

d. Construction schedules are as mentioned in Section 3.7.

The construction cost is composed of costs required for land acquisition and compensation, cost for civil works, engineering and administration cost including that for foreign consultants and contingency.

The cost required for civil works is calculated by multiplying work quantity by unit cost. Unit costs are estimated on the basis of costs required for labor, materials, technicians for execution, depreciation cost of equipment, spare parts and operation cost of equipment, which are as shown in Table 3.8. These unit costs are included 10% for contractor's profit and 3% for tax. Cost for land acquisition and compensation is estimated based on the unit prices required for similar works in the area. The contingency is assumed at 15% of the sum of land cost and cost for civil works. Engineering and administration cost is assumed at about 6% of the cost for land acquisition & compensation,contingency and civil works.

The construction costs are classified into two components of local currency and foreign currency. The local currency component is composed of cost for land acquisition & compensation, domestic labor cost, cost for local materials, cost for engineering & administration of the executing agency and contingency.

The foreign currency is basically classified into direct foreign and indirect foreign currency components. The direct foreign currency component comprises the cost of equipment and materials to be imported and the cost of service by the foreign consultant. The indirect foreign currency component is the cost of imported crude materials such as crude oil, pig iron and imported equipment and their spare parts.

The conversion ratio of Peso to US$ and Yen used in the cost estimation are as follows:

₱7.5 = US$ = ¥225

The construction cost for the stepwise plan is estimated at ₱797 x 10^6 as shown in Table 3.9.

The maintenance cost after the completion of the project for the flood control facilities is assumed ₱4 x 10^6 per year which includes dredging cost of low-water channel and maintenance cost of facilities such as revetment, levee, culvert, etc. The cost of dredging of low-water channel as shown in Table 3.10, is a main part of maintenance cost. The annual maintenance cost is equivalent to 0.5% of total construction cost.

3.5 Economic Cost

Economic construction cost for the project is estimated taking into consideration deducting tax and contractor's profit for the construction cost. With respect to compensation cost for the paddy field and the fishpond where flood control facilities are installed, land compensation cost is evaluated in terms of negative benefit. The economic construction cost for the stepwise plan is estimated at ₱639.2 x 10^6 as shown in Table 3.11.

3.6 Flood Control Benefit

The flood control benefit of the project is the decrease in the flood damages by the proposed flood control project. Based on the inundation area and affected houses under present conditions, decreases in flood damages by the flood control project are estimated on the basis of the results of hydraulic analysis as shown in Table 3.12, applying the following values.

a) Unit price in paddy area was estimated on the basis of the values below:

Item	Unit	Irrigated Area	Rainfed Area
Gross income	₱/ha	8,415	3,890
Production cost	₱/ha	3,206	2,340
Paddy yield	t/ha	4.5	2.08

b) Unit price of damage to fishpond was assumed at ₱3,889/ha on the basis of the data on damage survey report of the flood of 1980.

c) Witn regard to damage to private properties including houses and livestock, due to the scarcity of data on the past floods, it is assumed that the unit price of damage to private properties is ₱3,000/house which is equivalent to about 20% of the estimated average private properties per one house in the area.

d) 35% of paddy damage was assumed as damages to private properties and public facilities, and indirect losses in the North Candaba Swamp, based on the damage survey report of the flood of 1960.

e) 300% of damage to private properties was assumed as damages to public facilities in the area of the South Candaba Swamp and the downstream area below Sulipan, Calumpit on the basis of the data on the flood in 1978.

f) 5% of direct damage was assumed as indirect losses.

The flood damage to paddy depends upon the water depth, duration of flood, water velocity, muddiness of water and the growing stage of paddy.

Among these factors, water depth and duration are predominant. In this study, it is assumed that damage to paddy depends on the water depth and the duration of flood. The rate of decrease in yield of paddy is estimated using the correlation curve as shown in Fig. 3.9.

With regard to damage to private properties, it is assumed that the houses in flooded area are damaged when water depth increases to more than 1 m.

The flood control benefit accrued from the decrease in the flood damages for the stepwise plan is estimated at ₱85.2 x 10^6 in annual average as shown in Tables 3.13 and 3.14.

In this study, the negative benefit is defined as the loss of the primary profit. The estimated negative benefit is as follows:

Item	Unit	Q'ty	Unit Price (₱)	Amount (₱1,000)
Paddy Area (A class)	ha	46	5,209/1	240
Paddy Area (B class)	ha	730	1,550/2	1,132
Fishpond	ha	1,250	2,417/3	3,021
Total				4,393

Remarks: /1: Profit of irrigated paddy at present per a year
/2: Profit of rainfed paddy at present per a year
/3: Profit of fishpond at present per a year

With regard to the fish production to be increased for the existing fishpond in the upper area owing to channel excavation of the main Pampanga River, the benefit accrued from increased fish productivity is estimated on the basis of the following assumptions.

a) Unit values of fish production at present.

Item	Unit	Upper Area	Lower Area
Gross income	₱/ha	8,481	11,819
Produdtion cost	₱/ha	7,157	7,157
Productivity	Kg/ha	940	1,310

b) The fish productivity in the upper area is assumed to be reached the value in the lower area owing to channel excavation of the river.

c) The expected fishpond area to be increased in productivity is estimated at 2,021 ha based on the inspection survey.

d) The fishpond intakes to be constructed are required 26 nos. The construction cost is estimated at ₱1,820,000.

The benefit accrued from the increased fish productivity in the upper area is estimated at ₱6.7 million per annum.

The total of the annual flood control benefit amounts to ₱91.9 million on an average.

3.7 Project Implementation Schedule

3.7.1 Alternative Phasings and Period of Construction Works

In view of the large work volume involved, two phased implementations of the project are studied. The two phases involve 10-year execution in which the 1st phase continues from the 1st year to the 6th year and the 2nd phase, overlapping with the 1st phase in the 5th and 6th years, proceeds from the 5th year to the 10th year as shown in Table 3.15.

The alternative phasings studied are as follows:

Alternative - 1 Execution by stretch including all components of works

1st phase: Stretch between Candaba and Sulipan, Calumpit

2nd phase: Stretch below Sulipan, Calumpit

Alternative - 2 Execution by stretch including all components of works

1st phase: Stretch below Sulipan, Calumpit

2nd phase: Stretch between Candaba and Sulipan, Calumpit

Alternative - 3 Execution by component of works

1st phase: Construction of levee, excavation for embankment materials and related structures

2nd phase: Remained works

The 1st phase in Alternative-3 includes some excavation of low-water channel which is to be required for the materials of levee and base mound constructions. The typical cross-sections of the proposed channel for the 1st phase in Alternative-3 are shown in Fig. 3.10.

3.7.2 Flood Discharge

To examine the effects for each alternative phase, the flood discharge distributions for the first phase of the above alternatives are analysed as shown in Table 3.16 and Fig. 3.11, applying the probable flood of 20-year return period for Alternative-1 and Alternative-2 and 10-year flood for Alternative-3.